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Millennial-scale vegetation changes in the north-eastern Russian Arctic during the Pliocene/Pleistocene transition (2.7–2.5 Ma) inferred from the pollen record of Lake El'gygytgyn

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ABSTRACT

The sediment record of Lake El'gygytgyn (67°30′N, 172°05′E) spans the past 3.6 Ma and provides unique opportunities for qualitative and quantitative reconstructions of the regional paleoenvironmental history of the terrestrial Arctic. Millennial-scale pollen studies of the sediments that accumulated during the Late Pliocene and Early Pleistocene (ca. 2.7 to 2.5 Ma) demonstrate orbitally-driven vegetation and climate changes during this transitional interval. Pollen spectra show a significant vegetation shift at the Pliocene/Pleistocene boundary that is, however, delayed by a few thousand years compared to lacustrine response. About 2.70–2.68 Ma the vegetation at Lake El'gygytgyn, currently a tundra area was mostly dominated by larch forests with some shrub pine, shrub alder and dwarf birch in understory. During the marine isotope stages G3 and G1, ca. 2.665–2.647 and 2.625–2.617 Ma, some spruce trees grew in the local larch-pine forests, pointing to relatively warm climate conditions. At the beginning of the Pleistocene, around 2.588 Ma, a prominent climatic deterioration led to a change from larch-dominated forests to predominantly treeless steppe- and tundra-like habitats. Between ca. 2.56–2.53 Ma some climate amelioration is reflected by the higher presence of coniferous taxa (mostly pine and larch, but probably also spruce) in the area. After 2.53 Ma a relatively cold and dry climate became dominant again, leading to open steppe-like and shrubby environments followed by climate amelioration between ca. 2.510 and 2.495 Ma, when pollen assemblages show that larch forests with dwarf birch and shrub alder still grew in the lake's vicinity. Increased contents of green algae colonies (*Botryococcus*) remains and *Zygnema* cysts around 2.691–2.689, 2.679–2.677, 2.601–2.594, 2.564–2.545, and 2.532–2.510 Ma suggest a spread of shallow-water environments most likely due to a lake-level lowering. These events occurred simultaneously with dry climate conditions inferred from broad distribution of steppe habitats with *Artemisia* and other herbs.

1. Introduction

The transition from the late Pliocene into the earliest Pleistocene is an interval of dynamic environmental changes. During this transition glacioeustatic sea-level changes markedly increased in amplitude in response to intensification and increased fluctuation of Northern Hemisphere glaciation (Bailey et al., 2012). Generally, this interval at about 2.588 Ma covers the termination of the Pliocene, the most recent geological epoch with global temperatures several degrees higher than today, and the onset of the Pleistocene, the epoch of increasing climate extremes.

The high Arctic is particularly sensitive to climate changes. Recent studies have shown that during the last few decades the Arctic has experienced significant warming, more dramatic than in other parts of the globe (e.g. Sundqvist et al., 2010 and references therein). The rate of temperature increase of 2 °C since 1961 significantly exceeds that of the global mean (IPCC, 2007). With further temperature rise, the permafrost-dominated Siberian Arctic will likely turn from a main methane sink into a significant source of greenhouse gases (e.g. Schuur et al., 2009; Nisbet et al., 2014).

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